being a function of the size of the drops. A curiously distorted bow, observed by Linhart (Pernter, page 494), is explained by refraction by an intervening bank of mist. This appears to be a wholly inadequate explanation, as the presence of small drops of water in the air [or saturated air] can only affect its refractive index to a very slight degree, if at all. The masts of ships never appear distorted when seen through wisps of fog. A more reasonable way of regarding the phenomenon seems to be to consider the distorted portion as a part of a halo seen upon the cloud bank, the actual rainbow being invisible through the mist.

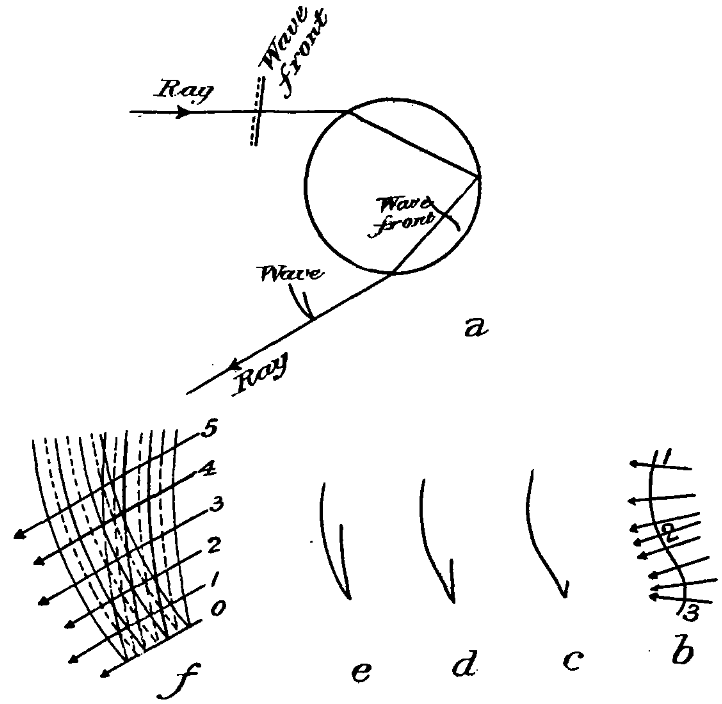

FIG. 3.

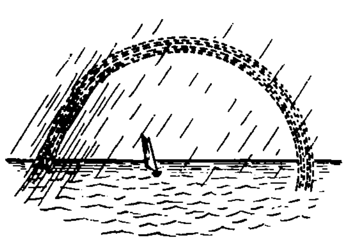
FIG. 4.

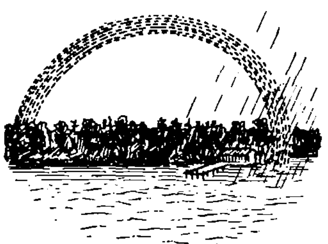
FIG. 5.

Two years ago, while discussing rainbows with Alexander Harrison, who has made an elaborate study of them from the artist's point of view, I was asked for an explanation of why the bow sometimes departed from a true circular arc. Never having observed a case of this kind, or seen any description of one, I expressed some doubt as to whether it were possible. Mr. Harrison assured me, however, that he had frequently seen the lower end of the bow slope off in a nearly straight line (as I have roughly sketched in fig. 4), and had attributed it to the fact that the rain curtain forming this portion was at a greater distance. Only a few weeks ago I observed a magnificent bow at Annisquam, Mass., which showed an unmistakable anomaly of this sort, the left half appearing pulled out into an arc of greater curvature, as shown in fig. 5. The right part cut across a distant bank of trees and well down upon the intervening water, the drops being not over 100 yards distant, while the left portion did not do so, and was evidently formed by a wall of rain at least half a mile away. I have been unable to find any case of this kind mentioned by Pernter. Possibly readers of the MONTHLY WEATHER REVIEW may have observed similar cases. The case which I saw this summer was so marked that it was at once noted by several people, whom I questioned as to whether the bow seemed peculiar in any way. It may be an illusion, similar to the apparent increase in the diameter of the moon when seen on the horizon, but I am inclined to regard it as real. It may be due to the fact that the cusp on the wave does not travel in a straight line, or in other words that the direction of the "least deviated ray" varies with the distance of the drop. It becomes noticeable, however, only when large distances are involved, for I have found that two jets of spray, one 60 feet from the eye and the other three, gave superposed rainbows. I have delayed this review in the hope of having a chance to throw up a jet of spray close to the eye and compare its bow with the one formed by a distant shower, but no more rainbows have appeared as yet.

EIFFEL'S "ETUDES PRATIQUES".

[Translation of a letter from M. Eiffel, dated Paris, France, April 12, 1906.]

In extending you my thanks for the very complete account [by the Editor] of my work, "Practical Studies in Meteorology", which you have been kind enough to publish in the October number of the MONTHLY WEATHER REVIEW, Vol. XXXIII, p. 442, I permit myself to make the following remarks:

1. In reference to the reading of thermometers to the tenth of a degree, I am of the opinion that in the observation of natural phenomena as complex as those studied by meteorologists it is not desirable to seek the precision necessary for the physicist and the chemist in investigating phenomena which are largely of their own creation in their own laboratories, for the reason that such precision would be purely illusory. We may convey an impression of accuracy by calculating, if we will, monthly means to the hundredth of a degree, but this does not constitute any real progress in science. Moreover, in the American observations, tenths of degrees are not observed in reading the maximum and minimum thermometers, from which eventually the mean monthly temperatures are determined.

2. The author of the article does not give my reason for preferring the meteorological year, commencing with December, to the civil year, commencing with January. It is simply in order to enable us to group the months by seasons. In our climates these seasons possess such distinct characteristics that it is advantageous to group the months accordingly, and this can be accomplished only by considering as winter the months of December, January, and February. December must not be classed an an autumn month, nor March as a winter month. It appears to me that such a grouping is useful; that by years combines elements which exhibit wide discrepancies.

3. The division into decades appears to me advantageous because it permits the deduction of means that are not too comprehensive, whereas those for a whole month include elements that are very unequal. In such means the irregularity of the final decades is of scarcely greater importance than that due to months of 31, 30, and 28 days.

4. There must be some misunderstanding as to what is said about mean solar time and the note in reference thereto. I have nowhere considered *true* solar time, but *mean* solar time, either civil or local.

5. I think it a duty to recommend the use of diagrams, especially the last that I have constructed, and two of which refer to the reading of the psychrometer, inasmuch as, when traveling, they replace the more or less voluminous tables, and even for the final reductions made at the office they are more rapid than the tables, as has been found by M. Moureaux, Director of the Observatory of St. Maur, who has made actual time tests. Moreover the diagrams furnish direct solutions

that are not given by the tables; for example, the weight of water vapor when the relative humidity and the temperature are given, or the two temperatures of the psychrometer.

STUDIES ON THE THERMODYNAMICS OF THE ATMOSPHERE.

By Prof. Frank H. Bigelow.

VII.—THE METEOROLOGICAL CONDITIONS ASSOCIATED WITH THE COTTAGE CITY WATERSPOUT.

The data that have been collected regarding the meteorological conditions prevailing at the time of the Cottage City waterspout are sufficiently extensive and accurate to enable us to study carefully the causes that produced the phenomenon, and to derive several important results regarding the formation of lofty cumulo-nimbus clouds and the dynamic actions going on within them. In this instance we can compute approximately the forces producing the ascension of the buoyant vapor in the cloud, the formation of hail and the energy working in the vortex at the base of the cloud which developed as the waterspout. I shall proceed to give these facts in detail, as this computation may serve as a type to be followed in discussing other cases of similar local atmospheric action.

Besides the formation and dissipation of the tube, noted in the several reports and shown in figures 27–36, there are special features to which attention must be directed: (1) In the third appearance the vortex tube shows a gradual tapering of the form from the cloud to the sea level, but in the second appearance the tube seems to have about the same diameter from the cloud to the sea level. It is necessary to account for this divergence in the type. (2) The photographs show a peculiar set of boundary curves in the cloud level which depend upon certain dynamic forces that we shall attempt to discover. (3) At the foot of the tube, near the sea level, there was a great commotion of the waters, with a white nucleus just under the tube, and finally a beautiful cascade of imposing dimensions surrounding it. These are topics of especial interest besides those usually considered in discussing such vortices.

The meteorological conditions are given quite fully by the regular observations of the neighboring Weather Bureau stations, Nantucket being a station of the first order and having a continuous barograph and thermograph record; Woods Hole, a station of the second order, with complete daily evening observations; and Vineyard Haven, a station of the third order, with daily temperature, wind, and cloud reports. The daily weather map of 8 a. m., August 19, 1896, exhibits the general conditions for the United States, and from it can be obtained the local conditions prevailing at that hour, at least approximately. The physical appearance of the waterspout has been described fully in the reports already given, and there is also a series of notes of which further use will be made in the proper places. We shall endeavor in this Section, VII, to discuss the scientific problems which are naturally suggested by these data, with the view of illustrating typical methods of treating waterspout and tornado phenomena whenever these occur.

METEOROLOGICAL CONDITIONS FOR AUGUST 19, 1896.

Vineyard Haven, Marthas Vineyard, Mass.—The Journal for this station has been given as the report of W. W. Neifert, the observer, in the preceding Section, VI, page 307, extract A.

Nantucket, Mass.—The Journal for this station has been given as the report of Max Wagner, the observer, on page 309, extract C.

Woods Hole, Mass.—The report for this station has been given as the report of J. D. Blagden, the observer, on page 309, extract D.

This last report also adds:

Clear during the forenoon, partly cloudy during the afternoon. Thunderstorm: thunder first heard, 1:58 p. m.; loudest, 3:02 p. m.; last, 3:50 p. m. Storm came from the northwest and moved toward the southeast; temperature before the storm 66°, after 67°; direction of the wind before the storm northwest, after, northwest; during the storm the wind shifted to the northeast. Rain began 2:55 p. m.; ended 3:20 p. m.; amount 0:33 inch. Maximum wind velocity 38 miles per hour from the northwest, at 3:00 p. m. A few hailstones fell about 3:10 p. m., and quite a heavy fall of hail was reported a few miles north of this office.

The weather map of August 19, 1896, is represented as fig. 37.

In Section A of Table 50 the meteorological data are given for Woods Hole, Vineyard Haven, and Nantucket on August 19, 1896. They are extracted from Forms 1001–Met'l. of Woods Hole and Nantucket, and Form 1004–Met'l. of Vineyard Haven. The notation is as follows: B= barometric pressure; t=dry-bulb thermometer; t_1=wet-bulb thermometer; d=dew-point; R. H.=relative humidity; e=vapor tension; Max. t and Min. t=maximum temperature and minimum temperature for the periods ending at the respective times of observations; Dir.=direction and Vel.=velocity of the wind; Amt.=amount of precipitation; Amt.=amount; Kind; Dir.=direction from which the clouds came; Local time=hour of making the regular observations.

In Section B are given the meteorological data at the evening observation for ten days immediately preceding, and ten days immediately following the date August 19, 1896, with the purpose of showing the kind of August weather prevailing in that locality.

In Section C are given data at alternate hours obtained from the continuous self-register of the pressure and the temperature for Nantucket during August 19, 1896.

PROBABLE CONDITIONS NEAR THE WATERSPOUT.

The general chart for August 19, 1906, fig. 37, shows that an area of high pressure was central over the upper Lake region, with its eastern edge just overlapping the southern New England coast. This anticyclone was advancing quite rapidly for the summer season, and on the following day, August 20, it extended far eastward over the ocean. The winds were light to fresh from the north and northwest over New England, and the advancing border of the area of high pressure produced a showery condition with precipitation in eastern Maine, the upper St. Lawrence Valley, and on the Massachusetts coast. Later in the day several thunderstorms developed in the neighborhood of Vineyard Sound, such storms being reported as follows, seventy-fifth meridian time:

Station.	Began.	Loudest.	Ended.	Precipitation.
Woods Hole	1:58 p. m.	3:02 p. m.	3:50 p. m.	2:55 to 3:20 p. m.; 0.33 inch.
Vineyard Haven	1:45 p. m.	3:04 p. m.	3:45 p. m.	3:04 to 3:30 p. m.; 0.38 inch.
Nantucket*				2:40 to 4:00 p. m.; 0.03 inch.

**Note by observer at Nantucket, Mass.*—An ordinary thunderstorm was already passing across the sound, when about 12:40 p. m. a huge black tongue shot down from an alto-cumulus cloud that floated half a mile high at the northern edge of the shower.

Several observers mention the thunderstorm that occurred in the neighborhood, in connection with the formation of the waterspout at the base of a large cumulo-nimbus cloud. The day had been generally calm, the breeze being about three to six miles per hour from the northwest. There was a pronounced turbulent congestion of the atmosphere along the southeastern edge of the anticyclone, also a strong convectional movement in the vertical direction, as was indicated by the rapid formation of clouds, the production of precipitation, and the generation of thunderstorms accompanied by an overturning of the strata. All these are consequences attending the flow of cold anticyclonic air over the ocean, causing abnormal temperature stratifications to be superposed upon the ordinary quiet arrangement due to solar insolation taken by itself. The readjustment of the thermal equilibrium, which had become much congested, gave rise to the phenomena